A STUDY OF LAKESHORE RESERVATIONS OF PINE
QUETICO PROVINCIAL PARK - ONTARIO

by

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I - INTRODUCTION

Since 1927 the Ontario Government has required the reservation of timber along lakeshores in provincial parks, when land areas in the parks are being harvested of a timber crop. Thus in 1943, when white and red pine, (Pinus Strobus L., and P. resinosa Ait.), was to be taken from land on the north side of Basswood Lake and vicinity, Quetico Park, (Figs. 1 and 2) shoreline reservations were marked out and left. In some cases these extended far enough back from the lake to hide the bare slopes of the cutover; in other cases the timber reserved along the shore was only a narrow strip about 100 ft. wide.

More recently the government has widened the scope of its regulations regarding the reservation of timber. A policy has been instituted whereby reservations must be left along all navigable rivers and lakes and all main roads on public land. Even at the time when shore reservations were required only in provincial parks, woods workers contended that the inevitable blowdown in the reservation

was a serious waste of timber. Since the practice now applies to logging operations on all public lands, the question of the purpose and possible success of the lakeshore reservations has become even more important. In the summer of 1953, the Basswood Lake cut was 10 years old. The time was ideal for investigation of the developments in the pine shore reservations there.

With the establishment of the Quetico-Superior Wilderness Research Centre on Basswood Lake in 1949, "Conducted for cooperative research by scientists of Canada and the United States in mattters relating to wilderness values", facilities were provided for investigators from the University of Toronto to take part in forest research in the Quetico area. Accordingly, this thesis is the report of a graduate student who, in 1953 along with Geoffrey Pierpoint, a student forester, was sent to the QSWRC to study the Lakeshore reservations of pine. Dean J.W.B. Sisam, Professor R.C. Hosie, and Dr. C. E. Atwood, all of the University of Toronto, collaborated in arranging finances and in the initial direction of the project toward the study of shore reservations. The author wishes to express to them and to Clifford E. Ahlgren and the staff of the QSWRC,

appreciation for their co-operation and assistance in this work.

The Problem

The forest studied in the Basswood Lake area is composed mainly of red and white pine, 120 to 250 years old and is frequently marked by fire scars, especially along exposed hilltops. However, pine stands do not form a continuous cover-type, but are interspersed with low-lying areas of spruce-fir forest. Hence the pure stands of pine cut in 1943 were usually on well-drained, moderate slopes, particularly those slopes facing toward the lake. Since the areas along the shore, not under pine, are usually low-lying spruce-fir sites extending back from the lake between moderate slopes, it is commonly found that some of the logged area on the slopes behind the spruce and fir is quite exposed to view from the lake. Aerial views show the shore reservations simply as patches or beads of pine, located wherever well-drained sites slope directly to the lakeshore.

The area of mature pine cut over was that which escaped the repeated forest fires that occurred in the area during the last 75 years. These fires had burned all around the pine stands several times. The natural

fire protection of the area is the lake which extends almost all around it, Fig. 2. Thus most of the study was restricted to a long point of land one-half mile wide, and extending a few miles south into Basswood Lake. Winds blow over this area from water on both sides of it and shoreline sites show the drying effect of this exposure to wind.

These then are the general conditions in which this investigation of ten-year-old shore reservations was made. Descriptive samples were taken to answer such questions as, whether there was significant growth improvement in the shore reservation resulting from cutting, and to what extent has seed from the shore reservation figured in the reproduction of the area cut over. Data were taken also on ground cover invasion of the shore reservation. The most difficult question, that of the extent to which aesthetic values were being maintained by reserving shoreline stands, was studied with the aid of photographs.

The Region

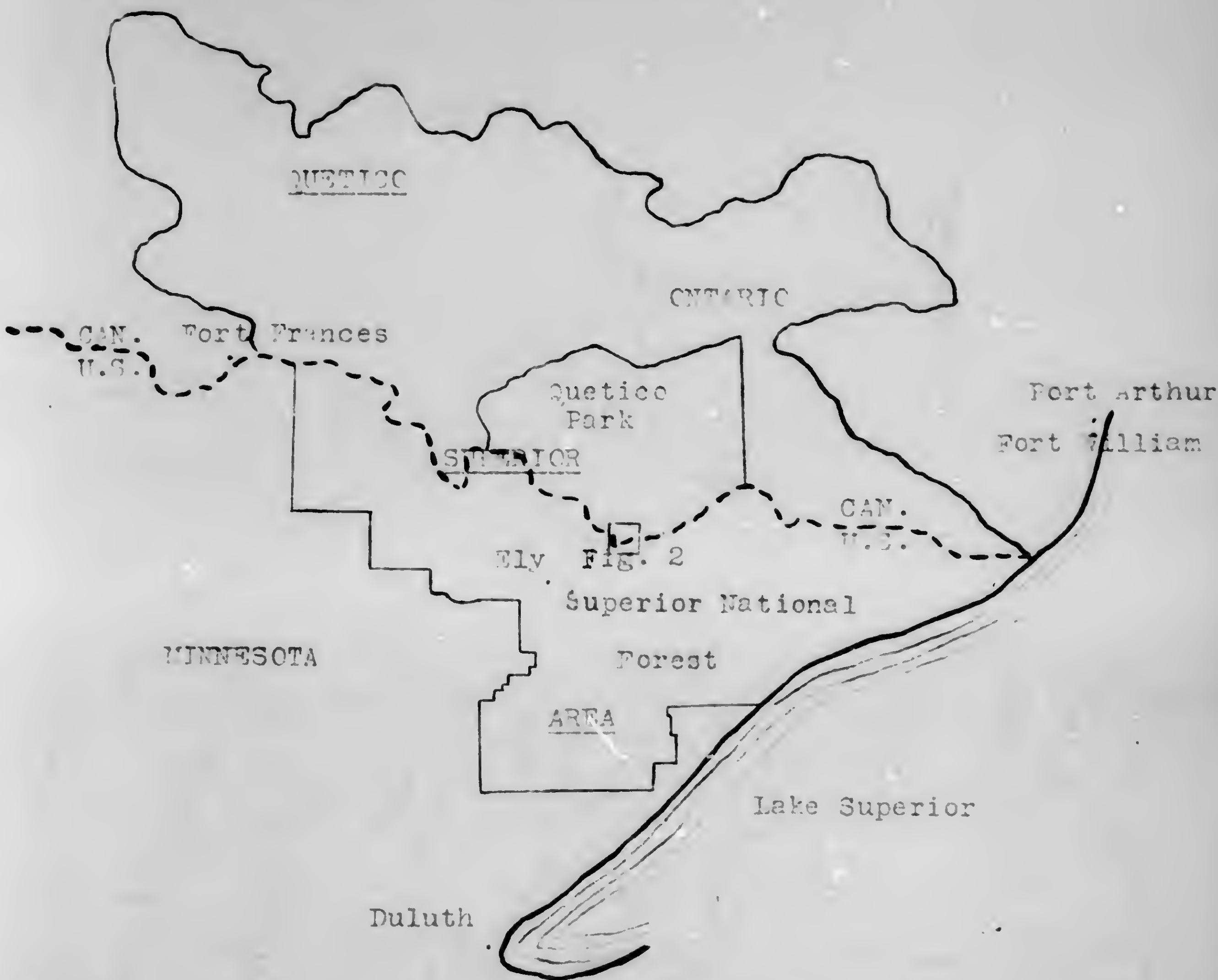
Basswood Lake is located in the heart of the Quetico-Superior country, (Fig. 1). The lake itself is on the International Boundary at the southermost tip of Quetico Provincial Park, about 20 miles northeast of Ely, Minnesota. This places the study area at about 91 degrees, 35 minutes west longitude, 48 degrees, 3 minutes north latitude.

The topography of this area is in general the steeply rolling terrain typical of much of the Canadian Shield. Lakeshores occasionally slope gently to the water, but are usually moderately steep, although the higher land seldom rises more than 100 to 150 feet above the level of the lake.

All bedrock materials underlying the areas examined are granitic schists, granites, and granodiorites, (Dept. Nat. Res. - Tech. Surveys Map). Bedrocks underlying areas ten miles east of the study area are precambrian sediments of the Keewatin and Couchiching series. Boulders from these bedrocks are common in the soils on the study area, and have had a moderate influence on the till development.

The most recent glacial advance on the area came from the northeast. It brought a red till,

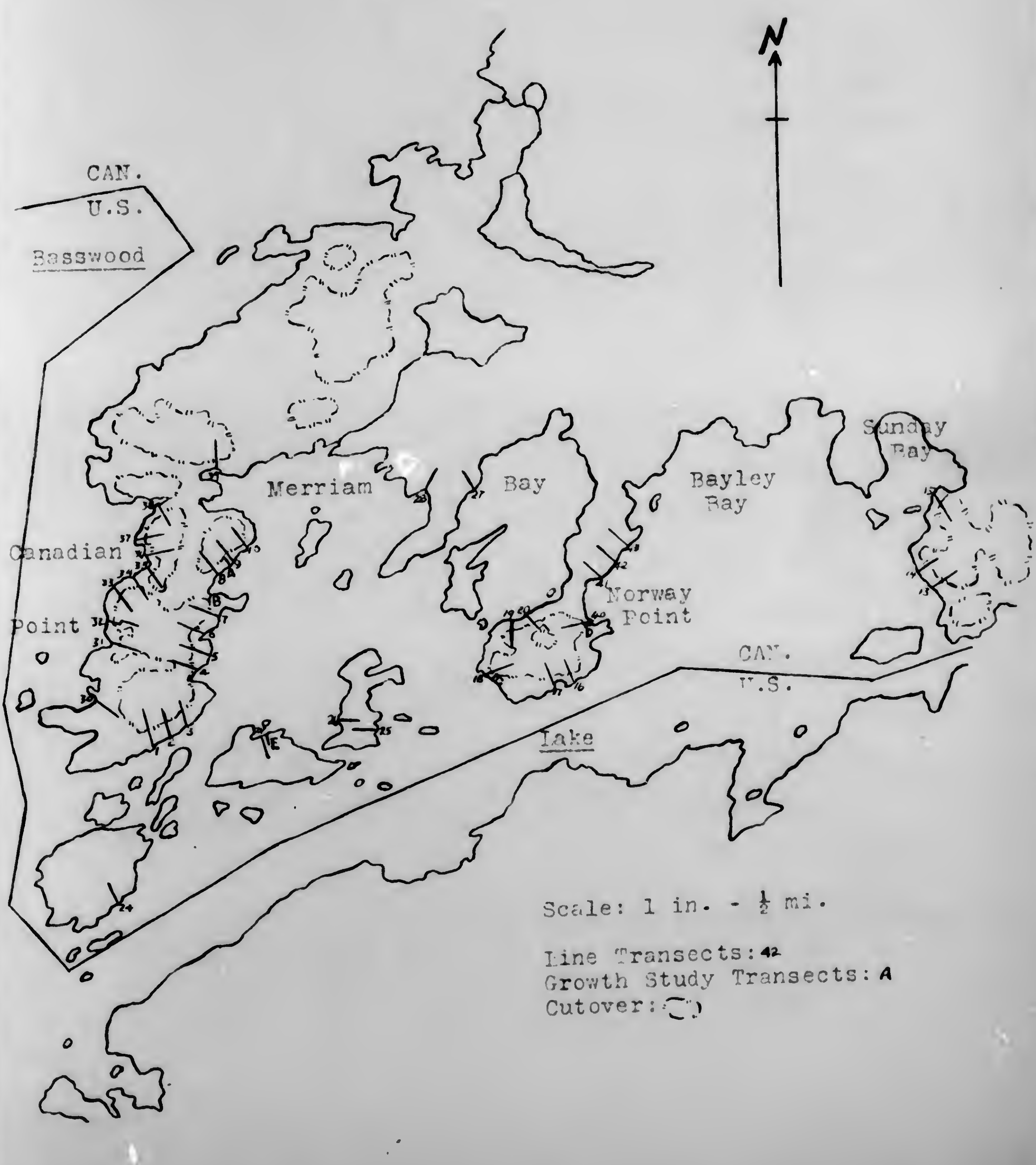
Figure 1



The Quetico-Superior Country
(After J.E. Potzger, Jour. of For., August, 1953)

Figure 2

The Basswood Lake Study Area



rich in argillaceous materials from the northeastern precambrian sediments referred to above . These materials were pushed over a grey limy till which had been brought from the northwest by an earlier ice advance. As the earlier ice had been retreating to the northwest, glacial pondings had developed between the ice front and the height of land southeast of the study area. As a result, rich deposits of slightly limy clay were deposited on low-lying sites and lower slopes of the Basswood Lake area. The more recent red till deposits are usually a foot deep over the clay deposits, though in low-lying areas there has been a little mixing of the two. In a few places the soil materials consist of recent alluvial deposits of silt and sand developed in a recent lake whose level must have been about 40 feet higher than the level of the present lake. Hilltops above the wash of this floodlevel have a moderately deep deposit of sandy red till over bedrock. Most of the rock outcrops lower than the level of the old lake but above the level of the present one, have been washed clear of soil materials.

The soils of well-drained uplands are podsols, though these are not strongly developed. The A_2 horizon is weak and usually less than 2" thick.

The B_2 is also rarely strongly developed and seldom extends more than two feet below the soil surface. On the other hand, many of the stands are growing on moss lithosols that have developed on the washed rock outcrops mentioned above.

The characteristic climate of this forest area resembles the climates of both the grassland to the southwest, and the boreal forest to the north.[1] Dry westerly winds from the Rocky Mountains meet the southeasterly flowing cyclonic disturbances from northwest Canada in this region. As a result, precipitation is greater here, throughout the year, than in the prairie 200 miles southwest of the area. This fact is borne out by the podsolic profile development in the soils of the area. On the other hand, late summer drought is common, and forest vegetation in general seems to reflect this influence.

From time to time, domination of the North American Grassland Region by prolonged summer droughts has been a serious setback to prairie border vegetation. One such critical drought extended into the Quetico

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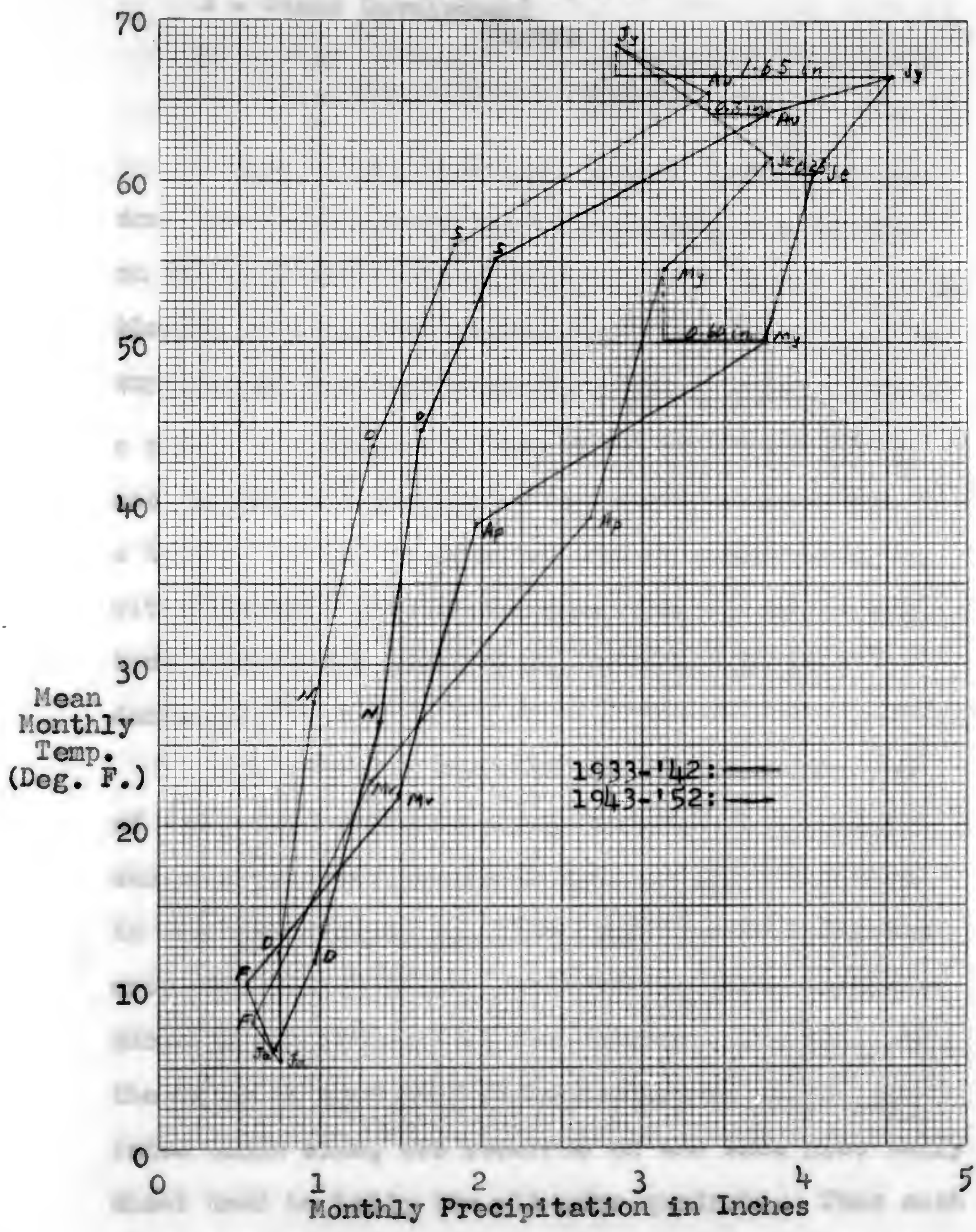
[1] Borchert, J. The Climate of the Central North American Grassland. Annals of the Ass'n. of Amer. Geographers: March, 1950.

Park Area from the prairie during the 1930's, and may have somewhat retarded forest growth. Such a difference in climate is clearly seen in the climatograph for Itasca State Park, Fig. 3. Mean monthly temperatures are plotted over mean monthly precipitation for the 10-year periods before and after the 1943 logging. Rainfall during the growing season has increased most during the last decade. Rainfall during May has improved by 0.6 inches; during June, by 0.25 inches; during July, by 1.65 inches; and during August, by 0.30 inches.

Figure 3

Climatographs of Itasca State Park, Minn.
1933-42, 1943-52



(Prepared from U.S. Weather Bureau Reports by E. V. Bakuzis, University of Minnesota, 1954, unpublished.)

II - INVESTIGATIONS

A - Stand Development

Investigative Method

Some of the questions raised by loggers and conservationists regarding the shore reservations on Basswood Lake have referred to the number of trees blowing down and, the number dying as a result of exposure or recovering and increasing growth rate as a result of release. Since these questions could not be answered adequately by casual observation, a type of cruise was carried out in conjunction with transects of mil-acre quadrats, to sample the tree stands, the vegetation, and the tree reproduction.

The mil-acre quadrats were taken at the end of every half chain of strip cruise. This spacing was used in order to obtain data on the transition in vegetative cover and tree reproduction along the cross-section of a shore reservation, from the lake-shore to the interior of the cutover. The tally of the trees on each half chain section of strip, one-tenth chain wide, was recorded on the same plot tally sheet used to tally the mil-acre quadrats. Thus each half chain forms a tree tally plot one-twohundredth acre in size.

These plots followed consecutively, making a continuous strip, or transect, of tree tally through the shore reservation stands, at right angles to the lakeshore, and extending as much as 10 chains further into the cutover, depending on the topography. A tree tally including cut stumps was also taken in the cutover, (except on line No. 1), so that comparisons could be made between the stands cut 10 years ago, and the shore reservation stands.

Plots taken in the cutover were divided into two classes: cut 'A', the two to five chains of strip tallied in the cutover closest to the shore reservation, and cut 'B', the remainder of the strip tallied in the interior of the cutover. This division was made so that reproduction in the area of the cutover bordering the shore reservation, could be compared with reproduction in the interior of the cutover. Hence cut 'A' was from two to five chains wide, depending on the topography. Cut 'B' is the entire interior of the cutover, and the length of strip taken in it also depended on topography.

Tree tally was taken of all stems by species and d.b.h. classes one inch and up, living, dead, and windthrown trees being recorded separately. Cut stumps were recorded by diameter inside bark. In the

later compilation, stump measurements were converted to Dbh-ob measurements as outlined in Appendix I. Condition of the dead trees, whether windthrown, or dead standing, or trees that had died before or since logging, was also recorded.

Thirty transects were taken through the shore reservation and on into the cutover. In addition, 13 control transects were taken on similar sites, through similar stands where no cutting had taken place.

From data obtained from these transects, total basal area and number of trees per acre were obtained for each plot. The total basal area of each plot was broken down to: basal area per acre now merchantable,[x] the basal area of the remainingtrees living but unmerchantable, the basal area of the trees that had died in the last 10 years, and the basal area of trees windthrown in the last 10 years. Then, for each transect, the average basal areas per acre were obtained for the shore reservation, Cut 'A', and Cut 'B', by averaging together the basal areas from the plots which were taken in each of these three divisions of the transect. Finally, the shore reservation

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[x]The minimum allowable stump diameters in force at the time of logging, 12" for red and white pine, and 10" for white spruce were taken as the standard for merchantable timber.

averages for the 30 transect samples were averaged together, to obtain average basal area, (along the above breakdown), and number of trees per acre for all shore reservations sampled. The same steps were taken for Cut 'A' and Cut 'B'.

Table 1, page 16, compares the average basal areas per acre. These are based on 30 transect samples for the shore reservations, 29 for each of cuts 'A' and 'B', 13 for the shoreline stands of the control transects, and 12 for the control stands away from the lakeshore.

It may be observed in the table that the merchantable basal area in the shore reservation (120.9 square feet per acre) is more than in either of the cut-over areas (107.0 and 103.7). A similar decrease in basal area per acre from the lakeshore to the interior of the stands is not borne out in the control data. However, in view of the comparatively small variation in the total basal areas per acre, especially between the shore reservation stands and the shoreline stands in the control, all stands sampled are considered sufficiently similar in structure for the comparisons that are to be made in this study.

Basal Area of Decimation

Most interesting are the figures for decimation in the shore reservations compared with decimation

Table 1

SHORE RESERVATION TRANSECTS

Shore Reservation	Merchantable* B*	Merchantable* N*	Unmerchantable B	Unmerchantable N	Total B	Total N
Trees alive now	100.4	73	76.8	745	177.2	818
Mortality in last 10 yrs.						
Wind-damage, blowdown	14.9	14	8.3	25	23.2	39
Dead - other causes	5.6	5	2.7	30	8.3	35
Total loss	20.5	19	11.0	55	31.5	74
Total - including decimation	120.9	92	87.8	800	208.8	892
Mortality before 10 years ago					12.7	96
Cut 'A'						
Trees alive now			48.8	732	48.8	732
Removal by cutting 10 yrs. ago	107.0	86			107.0	86
Dead and wind-damage, (Mortality since 10 yrs. ago)			20.1	42	20.1	42
Total - including decimation	107.0	86	68.9	774	175.9	860
Mortality before 10 years ago					25.4	19
Cut 'B'						
Trees alive now			43.3	643	43.3	643
Removal by cutting	103.7	66			103.7	66
Dead and wind-damage, (Mortality since 10 yrs. ago)			23.3	59	23.3	59
Total including decimation	103.7	66	66.6	702	170.3	768
Mortality before 10 years ago					13.9	13

CONTROL TRANSECTS

Shoreline Stands	Merchantable* B*	Merchantable* N*	Unmerchantable B	Unmerchantable N	Total B	Total N
Trees alive now	97.3	71	86.0	773	183.3	844
Mortality in last 10 yrs.						
Wind-damage, blowdown	3.8	3	1.3	10	5.1	13
Dead - other causes	4.5	3	8.3	78	12.8	81
Total loss	8.3	6	9.6	88	17.9	94
Total - including decimation	105.6	77	95.6	861	201.2	938
Mortality before 10 years ago					11.8	12
Control Stands Away from Lakeshore						
Trees alive now	112.7	63	68.5	569	181.2	632
Mortality in last 10 yrs.						
Wind-damage, blowdown	1.8	2				
Dead - other causes	7.7	8				
Total loss	9.5	10	11.9	66	21.4	76
Total - including decimation	122.2	73	79.4	635	202.6	708
Mortality before 10 years ago					3.9	6

B* - Basal area per acre in square feet.
N* - Number of trees per acre, 1 inch and up.
Merchantable* - 12" d.b.h. and up for red and white pine;
10" for white spruce.

in shoreline stands of the control. One would expect that any real difference in decimation between these two areas would result from accelerated mortality in the shore reservation since it was exposed along the side adjoining the cutover.

The total tree mortality during the last 10 years in the shore reservations was 31.5 square feet per acre, compared to 17.9 square feet in the control area. Trees dying from causes other than windthrow made up 8.3 square feet of this mortality in the shore reservations, and 12.8 square feet in the control area. Since mortality from causes other than windthrow is less in the shore reservation than it is in the control, it is apparent that there has been no increased mortality of trees in the shore reservations due to the exposure from the adjoining cutover.

Wind damage and blowdown account for the rest of the mortality--23.2 square feet in the shore reservations compared to only 5.1 in the control area. These data suggest that damage to the shore reservation from wind is about four times as much as should be expected in shoreline stands.

However, 23.2 square feet per acre was the average mortality from wind on the 30 shore reservation samples. Examination of the figures for wind damage and

and blowdown on each transect reveals that in 25 of the 30 shore reservation samples mortality from wind was quite comparable to mortality from wind in control stands. It was in only 5 of the 30 samples that blowdown was severe. Seventy-six per cent of the total basal area of all wind damage and blowdown encountered on the 30 shore reservation samples was recorded on these five.

It would seem from these observations that damage from wind to shore reservations is rather hit and miss. It may be either very heavy, or, no heavier than that found regularly in undisturbed stands. Accordingly, it is possible that if the five areas where blowdown has occurred had been recognized (by site characteristics which will be discussed), and clear-cut at the time of logging, serious wastage from wind damage to the shore reservations might have been avoided.

Mortality occurring in the stands more than 10 years ago, before the time of logging, is also indicated in the table. These figures are compiled from the records of dead trees estimated to have died before any logging took place in the stand. They are a rough estimate of the natural decimation in these

stands during the decade prior to logging. These data bear out the fact that mortality in the shore reservation before logging, 12.7 square feet per acre, agrees with that in the control, 11.8 square feet.

Rate of Growth in the Shore Reservations

In addition to the 30 shore reservation transects, and the 13 controls, five transects were run through shore reservations to obtain information on the growth rate of the trees left. These lines were one-tenth chain wide, and three to five chains long, depending on the width of the shore reservation. The following information was taken on all living trees: total age at breast height; diameter increment at BH in the last 10 years and in the 10 years prior to cutting; and the d.b.h. by diameter tape measurement. Four of these transects were taken in typical shore reservations. One of them faced north, one east, one south, and one west. The fifth was a control transect, and was established on a similar site, in a similar stand, but extended into an uncut area. The growth measurements obtained are summarised in Appendix II.

Table 2, page 20, summarizes the growth rate

Table 2

SUMMARY OF GROWTH RATE DATA

	(1) 1st. ch. from shore			(2) 3rd ch. from shore			(3) Last ch. from shore		
	Avg. age at BH.	Growth at BH. Last 10 yr.	Growth at BH. Prev. 10 yr.	Avg. age at BH.	Growth at BH. Last 10 yr.	Growth at BH. Prev. 10 yr.	Avg. age at BH.	Growth at BH. Last 10 yr.	Growth at BH. Prev. 10 yr.
Transects Through Shore Reservations									
Red pine	137	0.25"	0.33"	170	0.31"	0.21"	154	0.30"	0.21"
Number of measurements	14	14	14	13	15	15	15	17	17
Mean for last 10 yrs - 0.30" d.b.h. increment									
White pine	142	0.92"	0.98"	119	0.20"	0.13"	119	0.10"	0.13"
Number of measurements	4	5	5	3	3	3	2	2	2
Mean for last 10 yrs - 0.54" d.b.h. increment									
White cedar	150-	0.34"	0.36"	75-	0.60"	0.55"	-	-	-
Number of measurements	1	5	5	2	4	4	-	-	-
Balsam fir & White spruce	54	0.34"	0.36"	78	0.62"	0.32"	49	1.93"	0.99"
Number of measurements	2	2	2	3	3	3	5	5	5
Control Transect from Shoreline into Uncut Area									
Red pine	180	1.10"	0.90"	188	0.50"	0.45"	182	0.40"	0.27"
Number of measurements	1	1	1	2	2	2	9	13	13
Mean for last 10 yrs - control, 0.45" d.b.h.									

Mean for last 10 yrs., all tally, is 0.36" d.b.h. increment, based on 72 trees.

Table 2

SUMMARY OF GROWTH RATE DATA

	(1) 1st. ch. from shore			(2) 3rd ch. from shore			(3) Last ch. from shore		
	Avg. age at BH.	Growth at BH. Last 10 yr.	Prev. 10 yr.	Avg. age at BH.	Growth at BH. Last 10 yr.	Prev. 10 yr.	Avg. age at BH.	Growth at BH. Last 10 yr.	Prev. 10 yr.
Transects Through Shore Reservations									
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White cedar	150-	0.34"	0.36"	75-	0.60"	0.55"	-	-	-
Number of measurements	1	5	5	2	4	4	-	-	-
Balsam fir & White spruce	54	0.34"	0.36"	78	0.62"	0.32"	49	1.93"	0.99"
Number of measurements	2	2	2	3	3	3	5	5	5
Control Transect from Shoreline into Uncut Area									
Red pine	180	1.10"	0.90"	188	0.50"	0.45"	182	0.40"	0.27"
Number of measurements	1	1	1	2	2	2	9	13	13
Mean for last 10 yrs - control, 0.45" d.b.h.									

Mean for last 10 yrs., all tally, is 0.36" d.b.h. increment, based on 72 trees.

data presented in Appendix II for the shore reservations and the control. The data were grouped into three classes of material: one for the first chain length from the lake, another for the third chain length from the lake, and a third class from the end of the third chain to the edge of the cutover. Data for the second chain length, being intermediate between the lakeshore and the cutover, were omitted. First, third, and 'last chain' data were used in order to show any difference in degree of release across the width of the shore reservation.

Since there was no apparent correlation between d.b.h. class and present growth rate, or age class and present growth rate, all ages and diameter classes were averaged together in this comparison. It may be readily noted in the table that the stands are very slow growing. Comparing the control data with the shore reservation data for red pine, it may be noted that during the last ten years the control stands have been growing faster than the shore reservations. However, it may be noted too that the control stand was growing just as much faster than the shore reservation during the decade prior to logging. This relationship holds for the data closest to the lake, for the data between the lake and the cutover,

and for data closest to the cutover, presented in columns (1), (2), and (3). Hence, the present number of measurements are not enough to show any increased or decreased rate of growth for red pine in shore reservations. Accordingly, it appears that growth rate of pine in the shore reservation has not been influenced appreciably by the removal of competition through logging. A few young stems of balsam fir and white spruce near the edge of the cutover are the only exceptions, and these, as one would expect, have about doubled their growth rate.

It may be noted also that red pine in both the shore reservations and the control shows an increased rate of growth during the last decade compared to the previous one. Part of the reason for this unusual growth in the control area may be accounted for by the increased summer precipitation during the 10-year period since the time of logging, as indicated in the climatograph for Itasca Park, Minn., Fig. 3. Comparison with other typical climates of North America[1] shows that the Itasca climate for the 1933-42 period is most similar to that usual in a short grass prairie

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[1] Oosting, H. J. Plant Communities. W. H. Freeman and Co., San Francisco, 1953.

such as southwestern Saskatchewan. A moderate alleviation of this type of climate, especially during the growing season, could have a very beneficial effect on tree growth.

Control Area Stand Table

To obtain a better understanding of the structure of the shore reservation stands, and to compare them with the stands cut, a stand table was compiled from the control data.

Table 3 presents stem frequencies[x] per acre for red pine, white pine, balsam fir, white spruce and black spruce. The frequency in each diameter class is listed under the column headed 'n'. Also, inch diameter classes have been grouped by three's, and average frequencies have been obtained for the 3-inch diameter class groups, and are presented under the column '$\bar{n}$'.

Of the 13 cruise strips from which control data were obtained, 12 extended more than five chains from the lakeshore. Only the data from the first five chains, (10 plots), have been considered to be a shore

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[x]Frequency is used here in the mensurational sense of number of trees per acre.

Table 3

STAND TABLE - CONTROL AREAS

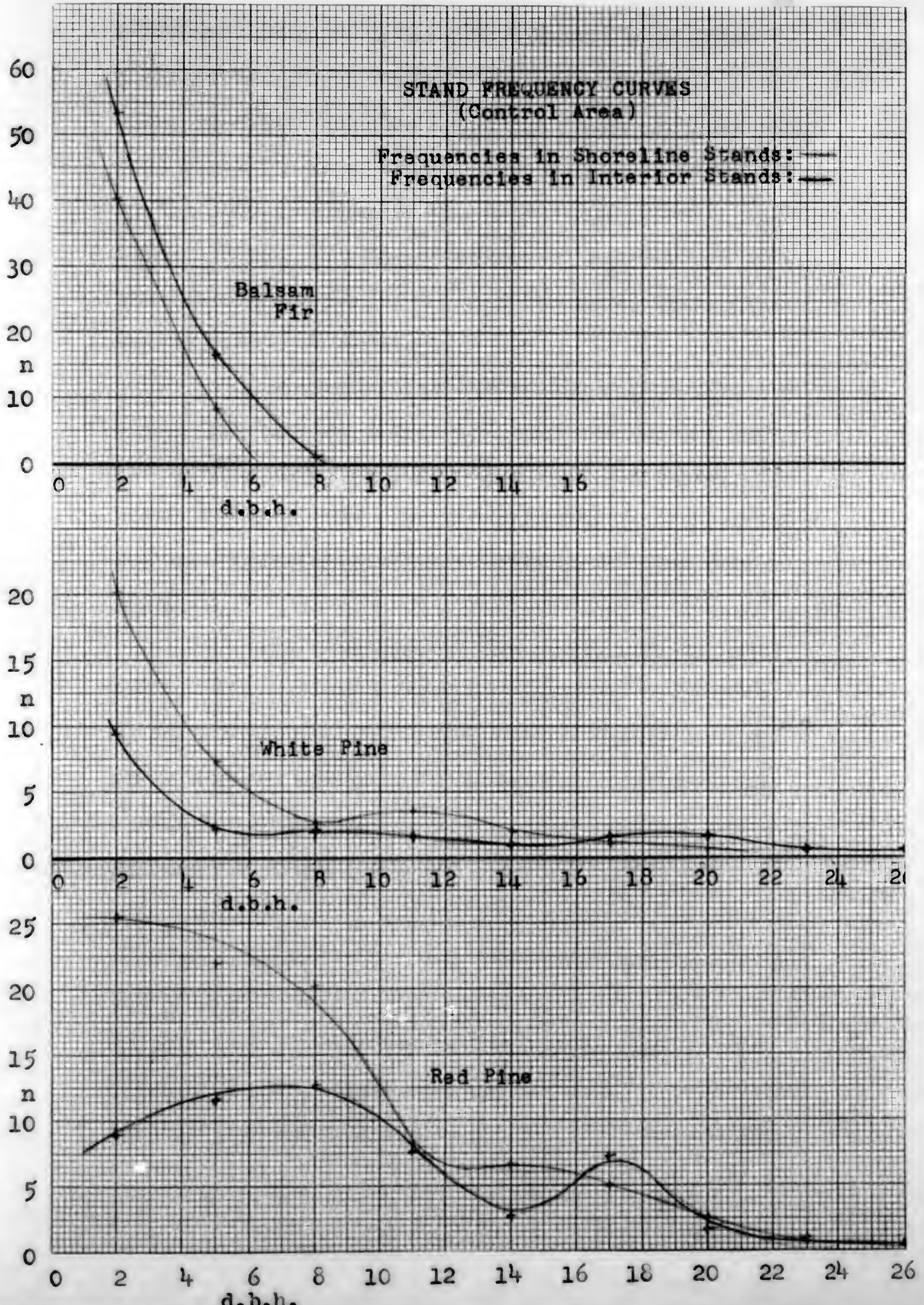
D.b.h. class	Shoreline stands										Stands over 5 chains from lakeshore									
	Red pine		White pine		Balsam fir		White spruce		Black spruce		Red pine		White pine		Balsam fir		White spruce		Black spruce	
	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$	n	$\bar{n}$
1	29		28		72		-		12		7		17		62		3		3	
2	20	25.6	25	20.2	34	40.3	-	0.5	8	8.6	8	9.0	8	9.5	62	53.7	5	3.9	3	5.0
3	28		8		15		2		6		12		3		37		3		8	
4	17		6		15		3		5		12		-		28		-		5	
5	18	22.0	6	7.2	6	9.1	2	1.6	3	3.1	5	11.7	2	2.2	10	16.7	7	3.3	2	3.9
6	31		9		6		-		2		18		5		12		3		5	
7	28		5		-		-		-		8		2		3		2		-	
8	15	20.3	3	2.6	-		2	0.5	-		15	12.8	2	2.2	-	1.1	3	1.7	2	1.1
9	18		-		-		-		-		15		3		-		-		2	
10	9		5		-		2		-		15		3		-		-		-	
11	8	8.2	5	3.6	-		2	1.0	-		5	7.8	-	1.7	-		-	0.6	-	
12	8		2		-		-		-		3		2		-		2		-	
13	5		5		-		-		-		2		2		-		-		-	
14	6	6.6	-	2.0	-		-		-		3	2.8	-	1.1	-		-		-	
15	9		2		-		-		-		3		2		-		-		-	
16	6		2		-		-		-		12		3		-		-		-	
17	5	5.1	2	1.0	-		-		-		5	7.3	-	1.7	-		-		-	
18	5		-		-		-		-		5		2		-		-		-	
19	6		2		-		-		-		2		2		-		-		-	
20	2	2.6	-	0.5	-		-		-		-	1.7	-	1.7	-		-		-	
21	-		-		-		-		-		3		3		-		-		-	
22	2		-		-		-		-		-		2		-		-		-	
23	2	1.0	-		-		-		-		-		-	0.6	-		-		-	
24	-		-		-		-		-		-		-		-		-		-	
25	2		-		-		-		-		-		-		-		-		-	
26	-	0.5	-		-		-		-		-	0.6	2	0.6	-		-		-	
27	-		-		-		-		-		2		-		-		-		-	
28	-		-		-		-		-		-		-		-		-		-	
29	-		-		-		-		-		-	0.6	-		-		-		-	
30	-		-		-		-		-		2		-		-		-		-	
31	-		-		-		-		-		-		-		-		-		-	
32	-		-		-		-		-		-		2	0.6	-		-		-	

reservation control, since, on the average, shore reservations were four to five chains wide. Data taken along the strip more than five chains from the lakeshore are considered to be a control for the stands cut 10 years ago. Accordingly, Table 3 presents one stand table for the shoreline stands, and one for stands over five chains from the lakeshore.

The averaged frequencies are presented in graphic form in Figure 4. Frequency over d.b.h. class has been plotted for both the shoreline stands, and the interior stands over five chains from the lakeshore. It may be noted that both controls are generally similar in stand structure if one considers only those trees 18 inches or more in diameter. Considering trees 8 to 18 inches d.b.h., there are fewer trees per acre in the interior stands, (blue curve), than in the shoreline stands, (red curve). On the other hand, in the smallest diameter classes, red pines become increasingly abundant in the shoreline stands, while in the interior stands they become less numerous. The white pine curves indicate that small stems of white pine are numerous in the interior stands, but they are even more numerous in the shoreline stands.

It may also be noted that the curves for both red and white pine appear to be bi-modal. The two

Figure 4


STAND FREQUENCY CURVES
(Control Area)
Frequencies in Shoreline Stands:
Frequencies in Interior Stands:
Balsam
Fir
White Pine
Red Pine
n
d.b.h.
0
2
4
6
8
10
12
14
16
18
20
22
24
26
5
10
15
20
25
30
40
50
60

modes reflected in these curves result from grouping together stands of two different age classes. Some shore reservations were about 130 years old, and some were about 50 years older. These ages are suggested by the data in Appendix II, particularly transects D and E. These same age classes were represented in the control stands for which these stand frequency curves have been drawn.

In the case of the curves for balsam fir, the higher frequencies are in the stands which are over five chains from the lake. Although the curves are close together, the absolute differences in frequency for each diameter class are vertical and are quite distinct.

One other feature of the control stands that may be obtained from the data presented in Table 3 is the proportion that white pine forms of the combined red and white pine frequencies. Table 4 presents these proportions for three diameter class groupings: under 9 inches, 10 to 18 inches, and over 18 inches. It may be noted that in diameter classes 9 inches and under, white pine stems make up about 30 per cent of the combined red and white pine, in both the shoreline stands and the interior. In diameter classes from 10 to 18 inches it forms 25 per cent of the stems in the shore reservation, and 20

per cent in the interior. However, for diameter classes above 18 inches it makes up only 11 per cent of the stems in the shore reservations, and 55 per cent in the interior stands.

Table 4

PROPORTION OF WHITE PINE IN COMBINED RED AND WHITE PINE FREQUENCIES

D.b.h. Group	Shoreline Stands	Interior Stands
Up to 9"	29%	30%
10" - 18"	25%	20%
18" and up	11%	55%

Net Increment in Last 10 Years

As one futher analysis of the shore reservations, the basal area increment of the tree stands during the last 10 years was obtained. This compilation is presented in Appendix III, and summarized in Table 5.

The total merchantable basal area of red and white pine alive now was computed from stand frequencies per acre, (Table 3), for d.b.h. classes 12 inches and over. The basal area figure of 95.8 square feet per acre obtained in this manner compares favourably with the figure 97.3 square feet given in Table 1, when a few white spruce which were included in the latter are

taken into consideration.

The merchantable basal area 10 years ago of trees left alive now was computed by taking the present diameters of the trees and reducing them by their diameter growth during the last 10 years. This has been done in Appendix III using the same stand frequencies as those used above in computing merchantable basal area alive now. The average red and white pine d.b.h. increment during the 10-year period was 0.45 inches. This figure is an average from all the growth data taken in merchantable diameter classes (12 inches and up), along the growth study transects presented in Appendix II. It is based on measurements of 40 red and white pine trees, in all merchantable diameter classes. The same diameter increment was used to obtain the merchantable basal area 10 years ago in both the shore reservations and the shoreline stands of the control area. Gross merchantable increment during the last 10 years in both the shore reservations and the control is now obtained by subtracting merchantable basal area 10 years ago of trees left alive now from present merchantable basal area.

The total merchantable basal area 10 years ago may be obtained by adding merchantable mortality during the last 10 years, (from Table 1), to the

Table 5

NET INCREMENT - LAST 10 YEARS

	Control Shoreline Stand (Sq. ft. per acre)	Shore Reservations (Sq. ft. per acre)
Total merchantable BA alive now: (Appendix III)	95.8	96.8
Gross merchantable increment: (Last 10 years)	5.0	5.2
Merchantable BA 10 years ago, of trees left alive now: (Appendix III)	90.8	91.6
Merchantable mortality, last 10 years: (Table 1)	8.3	20.5
Total merchantable BA 10 years ago:	99.1	112.1
Net increment	-3.3	-15.3

merchantable basal area 10 years ago of trees left alive now. The net increment is then the difference between total merchantable basal area alive now and total merchantable basal area alive 10 years ago.

It may be observed now that even the control stands have suffered a net loss in basal area of 3.3 square feet per acre in the 10-year period. The shore reservations however, have suffered an even more severe net loss of 15.3 square feet per acre.

This again is a good indication of the increased rate of deterioration in shore reservations after logging takes place. Nevertheless, the statements made earlier regarding the patchy characteristic of wind damage apply equally to the net increment figures since deterioration in the shore reservation during the last 10 years was largely wind damage.

B - Changes in Vegetation

Investigative Method

In addition to the changes taking place in the tree stand discussed in the preceding section, the removal of the tree cover by logging has produced a new pattern in the vegetative ground cover in both the shore reservation and the cutover near the shore reservation.

To determine the changes taking place, a record was made of the vegetation occurring on mil-acre quadrats taken at half-chain intervals along the line transects used to sample the tree stands. These transects extended as already indicated, first through the shore reservation, then into the area of the cutover designated as Cut 'A', and terminated in the interior of the cutover, designated as Cut 'B'. The thirty transects provided a total of 750 quadrats. Most of these quadrats were on productive pine sites, but as a few occurred in black ash or black spruce types, which were later isolated and discarded, the number used totals 712.

The same record of the vegetation was taken along the 13 transects made in the control area, providing an additional 250 quadrats. These quadrats

provide a record of the typical vegetative cover previous to logging.

In tallying, the vegetation for each quadrat was arbitrarily divided into three strata, or layers: (1) Ground layer--from 0 to 6 inches above the ground surface; (2) Lower plant layer--from 6 to 30 inches above the ground surface; and (3) High bush layer--from 30 inches above the ground surface to about 15 feet. Tree cover above 15 feet was usually close to 90 per cent of full crown closure in the shore reservations, and almost negligible in the cutover.

Complete vegetative cover for each layer was taken as 100 per cent. Thus each species occurring in a given layer was recorded as a percentage of the total vegetative area of the quadrat. The cover percentages were obtained by inspection. Thus, if Maianthemum canadense was scattered on the ground, but completely covered by aster leaves less than 6 inches high, the maianthemum was recorded as a 'trace'.

Changes in Degree of Cover

The most obvious change in the vegetative ground cover in the cutover and in the shore reservation near the cutover is the increase in the degree of cover. The percentages of quadrat cover made up by each ground

cover species, (woody or herbaceous), were added together within each of the three layers of ground cover. In this way a total vegetative cover in per cent was obtained for every quadrat at each layer.

From field observations it was clear that total vegetative cover under shore reservations was least along the lakeshore. It was somewhat heavier under the part of the shore reservation nearest the cutover. Accordingly, average degrees of ground cover were obtained for nine points along the shore reservation transects in order that a curve showing the gradual increase in ground cover from the lakeshore to the cutover could be drawn. These points were: the second quadrat from the lakeshore; the third quadrat from the lakeshore; the second last quadrat in the shore reservation; the last quadrat in the shore reservation; the first quadrat in the cutover; the second quadrat in the cutover; the second last quadrat in Cut 'A'; the first quadrat in Cut 'B'; and third quadrat in Cut 'B'. The last two points were randomly selected as representative of the interior of the cutover.

Thus the plots from which the ground cover averages were obtained were taken at the same relative position on each transect. Hence each average is based on 30 quadrat samples, each sample being taken at the

same relative position along each of the 30 shore reservation transects. These averages for the three layers of ground cover are presented in Table 6.

Similar steps were taken with the ground cover data recorded on mil-acre quadrats taken along the 13 transects in control areas. Again there were nine points selected along the transect, chosen such that a curve could be drawn through them to show an increase or decrease in total ground cover along the transect. These points were: the second and third quadrats from the lakeshore; the fifth and sixth quadrats from the lakeshore;(in approximately the same relative position as the last two quadrats in the shore reservation); the seventh and eighth quadrats from the lakeshore, (corresponding to the first two quadrats in Cut 'A'); the tenth and eleventh quadrats from the lakeshore, (corresponding to the last two quadrats in Cut 'A'); and the fifteenth and sixteenth quadrats from the lakeshore as random samples in the interior of the control area. Again it may be noted that the points for which average ground cover has been computed are at the same relative position along each control transect. In addition, these points have approximately the same relative positions as the points taken along the shore reservation transects. These averages also are presented in Table 6.

The data in Table 6 are shown graphically in

Table 6

AVERAGE DEGREE OF VEGETATIVE COVER

AVERAGE COVER PER CENTS AT RELATIVE POSITIONS ALONG TRANSECTS

Layer	Second Quadrat from Lakeshore	Third Quadrat from Lakeshore	Second Last Quadrat in Shore Reservation	Last Quadrat in Shore Reservation	First Quadrat in Cutover	Second Quadrat in Cutover	Second Last Quadrat in Cut 'A'	First Quadrat Cut 'B'	Third Quadrat Cut 'B'
Transects through shore reservations to cutover									
	%	%	%	%	%	%	%	%	%
Ground Layer	20.1	19.5	27.5	24.6	51.8	48.9	40.5	45.2	41.3
Lower Plant Layer	18.8	14.3	21.2	17.3	32.8	31.2	34.9	28.9	32.8
High Bush Layer	18.8	21.6	25.0	34.9	29.2	35.5	35.1	33.7	43.0
(Averages based on 30 samples)									
Transects through control areas									
Ground Layer	5.5	10.9	18.2	15.1	18.2	15.8	13.4	11.3	15.6
Lower Plant Layer	6.6	10.3	12.8	10.7	9.0	11.4	24.3	13.8	13.4
High Bush Layer	14.4	8.2	11.8	4.6	9.0	22.2	8.8	7.5	10.8
(Averages based on 13 samples)									

Figure 5

AVERAGE PER CENT GROUND COVER over
RELATIVE DISTANCE FROM LAKESHORE

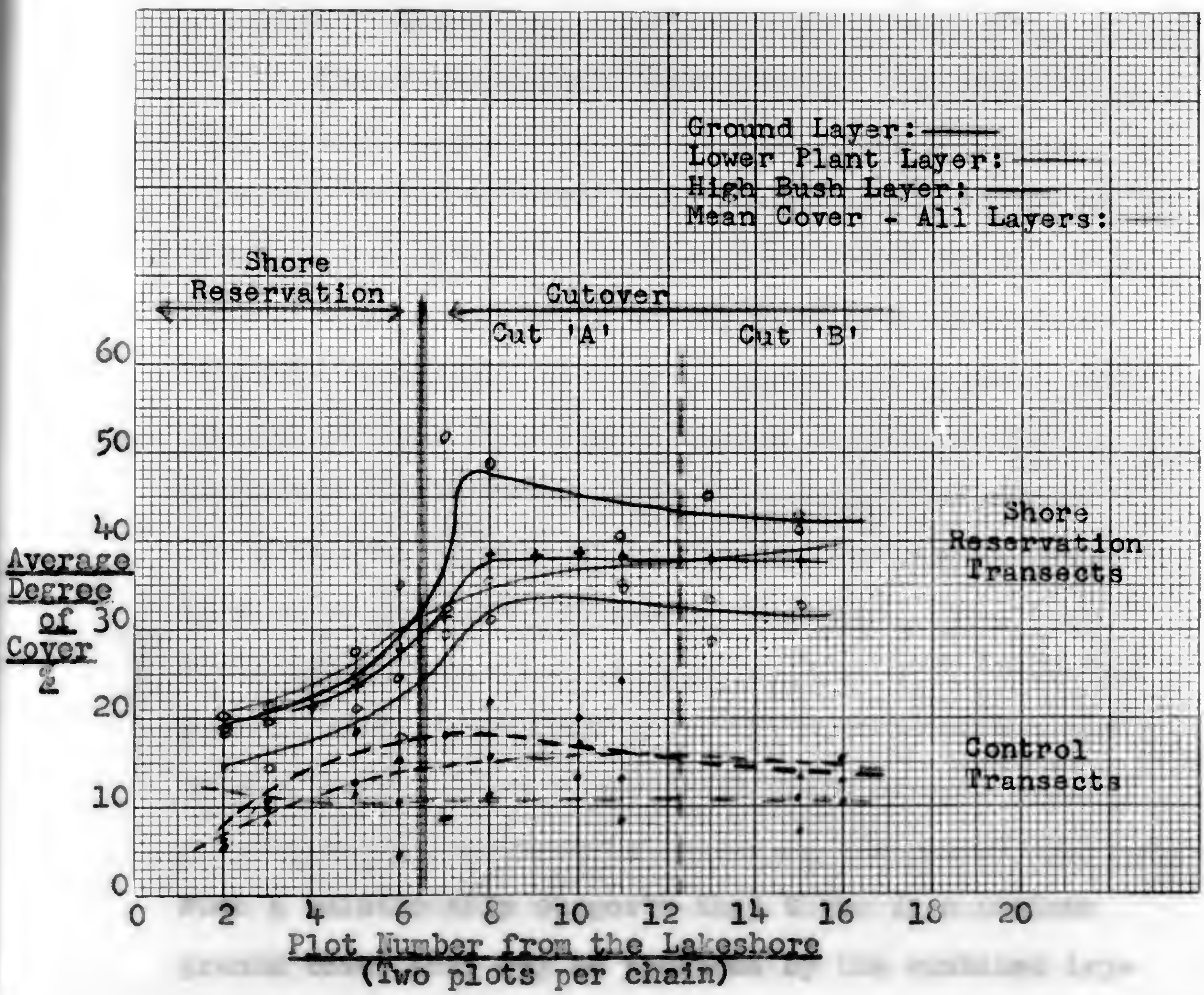


Figure 5 where average degree of cover in per cent is plotted over distance from the lakeshore. Since all averages obtained were relative to the distance from the lake, or the edge of the shore reservation, these two points - the lakeshore, and the cutover boundary - provide the scale, and all averages are plotted in relation to them.

The average ground cover curves in the control area show that ground cover is least near the lake. This may be due to some penetrations by the winds off the lake and severe drying of the ground surface. The ground layer vegetation, (green curve), reaches its fullest development at about 3 chains, (6 plots), from the lakeshore. The lower plant layer, (brown curve), is even further from the lakeshore before it reaches its best development, but at 5½ chains from the lake it becomes a larger percentage of quadrat cover than the ground layer. It may also be noted that after the ground layer reaches its peak, an increase in the degree of cover of the lower plant layer seems to effect a decrease in the degree of cover of the ground layer. Such a relationship suggests that there is a maximum ground cover that may be produced by the combined layers of vegetation, and that increased cover by the taller layers effects decreased cover by the shorter layers. Very little variation may be observed in the high bush

layer.

In contrast, the curves for vegetative cover in the shore reservation show marked correlations with the edge of the cutover. It may be noted that there is a very gradual increase in the degree of cover by the high bush layer. It is lowest in the shore reservation near the lake, and is highest in the interior of the cutover. There is no marked differentiation of this layer at the edge of the cutover. The ground layer, on the other hand, rises from a moderately low average cover just inside the shore reservation adjacent to the cutover, to a very high average cover a short distance inside the cutover. From this high, the per cent cover that it forms gradually decreases toward the interior of the cutover, as dominance by the high bush layer increases. This relationship again suggests that there is a maximum cover that may be produced by the combined layers of vegetation, and that at the very edge of the cutover there is a sharp increase in the maximum degree of cover obtainable.

To assess such a relationship, values of the average degree of cover on each plot were read from each of the three curves. The values from the three curves were then added together and averaged for each plot along the transect, to obtain the mean cover per cent effected by the three layers. These values are also plotted, (in pencil), in Figure 5. It may be

observed that the mean cover through the cutover shows almost no tendency to increase or decrease. Approaching the shore reservation from the cutover, only the quadrat closest to the shore reservation indicates the decrease in mean cover per cent which is characteristic of the interior of the shore reservation.

The above observations show that there is a strip of cutover adjacent to the shore reservation, and extending parallel to it two to three chains wide, in which development of the high bush layer appears to be restricted by the proximity of the tree stands, and ground layer vegetation is hence encouraged. Since a heavy cover of ground layer vegetation usually does not appear to restrict the development of reproduction to the extent that a heavy cover of brush does, it is possible that regeneration of tree species may be given some advantage along this strip.

C - Regeneration Pattern

General

In conjunction with the examination of changes in the stands of the shore reservation, a study of the pattern of reproduction around the edge of the cutover was also undertaken.

By the very nature of a shore reservation, mature trees, capable of bearing some seed every year and an abundance of seed in seed years, are in close proximity to the cutover. Accordingly, the degree to which this seed supply is effective in regenerating the cutover is of prime importance.

Many other studies have been carried out to investigate similar problems. Wood[1], found a significant seeding effect for 5 chains in the windward direction, and in the leeward direction for 10 chains, from a white pine seed source. He also noted that maximum seeding in following burns occurs after six to nine years, with no single year having an outstanding proportion of seeding in. The Lake States Forest Experiment Station[2], studied red pine seed tree operations

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[1]Wood, O. M. White Pine Seed Tree Reproduction Survey. Amer. Jour. For., Nov. 1932, 838-45.

[2]U.S. Forest Service, Lake States Forest Experiment Station. Effective Seeding Range of Red Pine. Technical Note No. 228, 1945.

in the Superior National Forest, in Minnesota adjacent to Quetico Park. It was found that the effect of red pine seed trees decreased rapidly beyond 40 feet from the seed source. It was also noted that seeding in since cutting made up only one-third of the reproduction present, though no indication is given as to what species are included in the one-third.

Rudolf Geiger[1], discusses The Climate of the Stand Border in his book on microclimate. He takes for his example coniferous stands left uncut alongside clear cuts in Europe. In addition to microclimatic moderations produced by the stand for a distance of one to two chains into the cutover, he found that seed dispersal, defined as 100 per cent at the edge of the cutover, dropped to 40 per cent at a distance of slightly less than two chains.

No useful information was obtained on the availability of seed in the cut-over areas on Basswood Lake at the time of logging. The Lake States Forest Experiment Station has, however, published technical notes on seed crop conditions in northern Minnesota for the last five years[2]. These data for red and

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[1]Geiger, R. The Climate Near the Ground. Translated by N. S. Milroy. Harvard University Press, 1951.

[2]U.S. Forest Service, Lake States For. Experiment Station. Technical Notes Nos.: 333, 349, 370, 393, 412. Published January 1950, '51, '52, '53, and '54 respectively.

white pine are summarized in Table 7.

Table 7

	1949	1950	1951	1952	1953
Red pine (per cent of full crop)	25%	75%	37-50%	7-25%	7-50%
White pine (" " " " ")	7%	75%	7-25%	7-25%	7-75%

These data indicate roughly a periodicity of three or four years for both species with at least a little seed available every season. Working back to the time of the 1943 logging operation in the Basswood Lake area, there probably was a seed year around 1946 or '47, and another before that, between 1942 and '44. Any of the years 1942, '43, or '44 would have provided a good seed distribution to the cutover, either before logging or very soon after.

Investigative Method

It was with these probable seeding possibilities and the stand conditions already described under tree cover and vegetative cover, that the reproduction on the Basswood Lake cutover became established. Data on the tree reproduction were taken on the same quadrats as those used to sample the vegetation. The tally was again divided into three zones: Shore Reservation proper, Cut 'A', and Cut 'B'. Actual reproduction was

tallied by species and age classes up to 10 years old. For stems more than 10 years old, reproduction was recorded in two sizes of advance growth. Particular care was taken with the division of regeneration under 10 years old from advance growth. Frequent checks by ring counts at the root crown were made of doubtful cases, especially in white pine, to maintain the accuracy of the division into advance growth, or reproduction since logging.

Distribution of Numbers of Reproduction Per Acre

The analysis of the reproduction data taken on the quadrats follows a pattern similar to that used for vegetative cover in the last section. In order to show the effects of the shore reservation on the pattern of reproduction at different points along the transect, certain standard points were again selected, and the average number of seedlings present were obtained for them. These points are: the first three quadrats in the shore reservation, (closest to the lakeshore); the last three quadrats in the shore reservation, (closest to the cutover); the first three quadrats in Cut 'A'; the last three quadrats in Cut 'A'; and the entire sample of quadrats in Cut 'B'. Each position is represented by three quadrats, (distributed over a linear distance of one chain), in order to obtain

a reliability of the 90 quadrat sample for that particular chain length rather than a reliability of three 30 quadrat samples. Cut 'B' again represents the interior of the cutover, and the average number of seedlings there is based on the entire sample of 234 quadrats.

The number of seedlings per acre at any of these positions was obtained by totalling the number of seedlings present on the three quadrats, summing for the 30 transects, and averaging for the 90 quadrats so sampled. This average is taken to be representative of the usual reproduction condition on the middle quadrat. Only reproduction more than two years of age has been taken into consideration. A summary of the average numbers of red pine and white pine reproduction is presented in Table 8.

These figures are presented graphically in Figure 6, page 47, where numbers of seedlings per acre are plotted over relative distance from the lakeshore or cutover boundary in the same manner that vegetative cover was plotted in Figure 5. It may be observed that about three-quarters of the white pine reproduction in the shore reservation is under 10 years of age and one-quarter advance growth. Almost the same relationship

Table 8

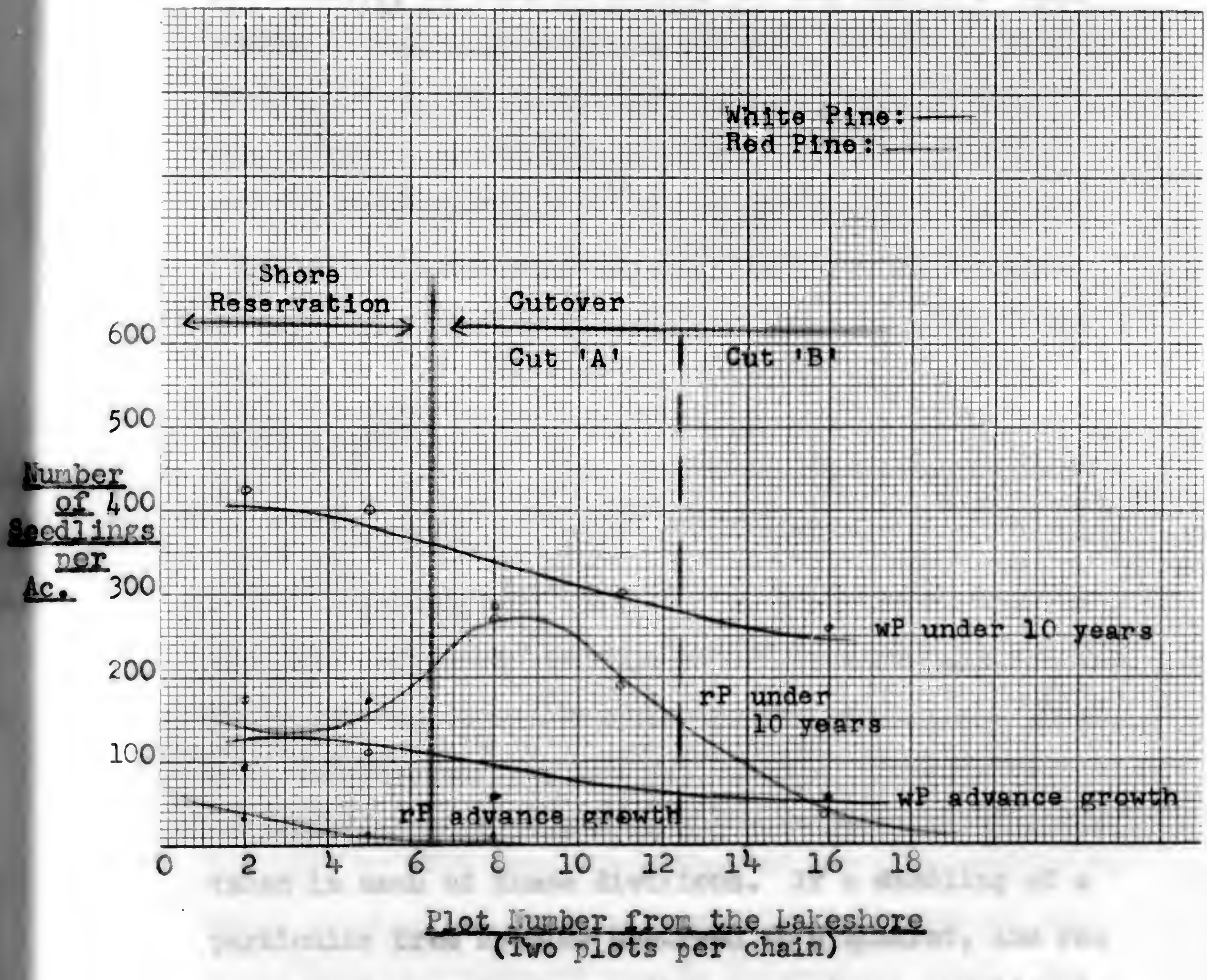
NUMBERS OF REPRODUCTION PER ACRE

Position along transect:	Shore Reservation First 3 plots	Shore Reservation Last 3 plots	Cut 'A' First 3 plots	Cut 'A' Last 3 plots	Cut 'B' All plots
	(Number of seedlings per acre)				
Red pine					
Under 10 years	170	110	270	190	40
Advance Growth	30	10	10	-	-
White pine					
Under 10 years	420	400	280	300	260
Advance Growth	90	170	60	30	60

holds through both cuts 'A' and 'B'. However, the reproduction over 10 years of age was established before the time of the logging 10 years ago. The pattern of reproduction since logging appears to follow a similar distribution along the transect. This relationship suggests that the white pine seed available from the shore reservation stands has had no apparent influence on the white pine seeding in since logging. (As was noted in the stand table, section A, about 20% of the trees in the shore reservation 10 inches and up in diameter were white pine, and 80% were red pine. Hence it is assumed that since white pine usually bears more seed than red pine, then white pine seed would be available to the cutover in numbers similar to those of red pine).

Figure 6

REPRODUCTION PER ACRE over DISTANCE FROM LAKESHORE



For red pine, the curves show a similar three to one relationship for the reproduction in that part of the shore reservation nearest the lake, but show a sharp divergence from this pattern on the side facing the cutover, as well as in Cut 'A' and Cut 'B'. The number of red pine under 10 years in Cut 'A' is double the number in the shore reservation, and many times the number in the interior of the cutover. This indicates that red pine in the Basswood Lake area will seed in cut-over areas adjacent to shore reservations to a greater density of reproduction than would perhaps develop in the usual cutover where no shore reservation is left.

Per cent Stocking

The important question is, however, whether an adequate degree of stocking is obtained through leaving shore reservations. The average stocking in the shore reservation, Cut 'A', and Cut 'B', was obtained by averaging together the stocking data from all quadrats taken in each of these divisions. If a seedling of a particular tree species occurred on a quadrat, and was two years of age or more, that quadrat was considered stocked to the species. The per cent stocking figures then are the percentages of mil-acre quadrats found stocked to certain species. Per cent stocking figures

for red pine, white pine, red or white pine, white or black spruce, and balsam fir are presented in Table 9. Averages for the shore reservation are based on 257 quadrats, for Cut 'A' on 221 quadrats, and for Cut 'B' on 234 quadrats. Average stocking in the control area is based 130 quadrats in the shoreline stands, and 120 quadrats in the interior stands. Since a 90 quadrat sample is too small for computing per cent stocking in a cutover, figures could not be obtained for the same relative points along the transect as were used in Table 8. On the other hand, because of the uniformity in the forest floor, the 120 quadrat sample in the control area is taken to be just as reliable as the 200 quadrat sample taken in cutover conditions.

The stocking percentages for red pine and white pine given in Table 9 are presented graphically in Figure 7, page 51. It may be observed again that in general there has been a sharp increase in the seeding in to red pine along a strip of the cutover, about three chains wide, and bordering the shore reservation. However, in this case the number of red pine seeding in since logging are being compared to the number of red pines under 10 years of age in the control area. The fact that the latter curve follows the same pattern as that observed for red pine advance growth seedlings on the shore reservation transects indicates that, in

Table 9

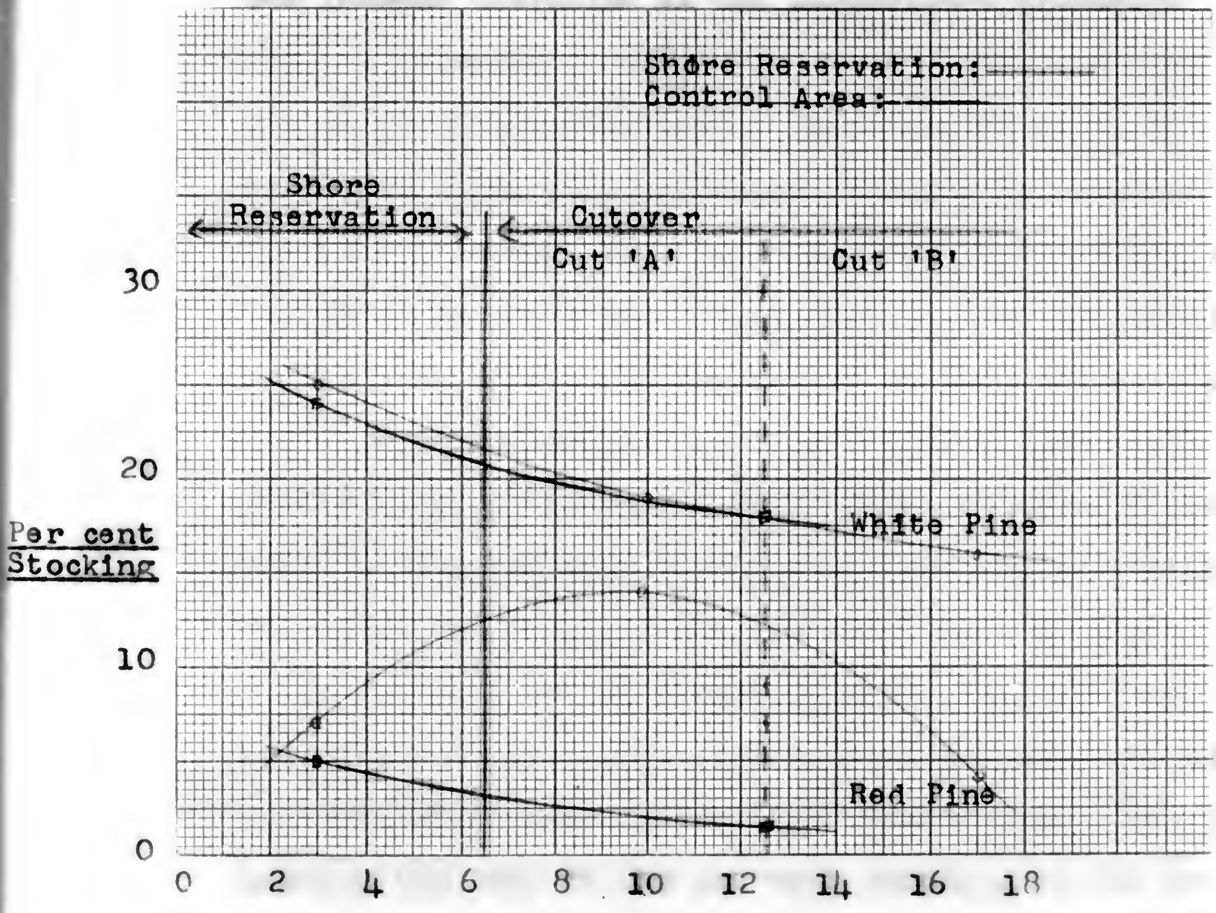
PERCENTAGES OF STOCKED QUADRATS

Shore Reservation Transects	Shore Reservation Per cent stocked	Cut 'A' Per cent stocked	Cut 'B' Per cent stocked
Red pine			
Under 10 years	7	14	4
Advance growth	1.5	0.5	-
White pine			
Under 10 years	25	19	16
Advance growth	10	6	3
Red or White pine			
Under or over 10 years	34	30	22
White or Black spruce			
Under 10 years	3	3	3
Advance growth	3	3	0.8
Balsam fir			
Under 10 years	21	17	20
Advance growth	18	13	17

Control Transects	Shoreline Stands	Interior Stands (Cut 'A' and Cut 'B')
Red pine		
Under 10 years	5	1.7
Advance growth	1.5	0.8
White pine		
Under 10 years	24	18
Advance growth	6	4
White or Red pine		
Under or over 10 years	29	22
White or Black spruce		
Under 10 years	0.8	3
Advance growth	5	1.7
Balsam fir		
Under 10 years	15	26
Advance growth	10	11

Figure 7

PER CENT STOCKING OVER DISTANCE FROM LAKESHORE



tallying, the division of the seedlings into reproduction since logging, or advance growth, has been reliable.

The curves for white pine again bear out the fact that white pine seeding in on the cutover since the logging operation is not appreciably different from the seeding in under the control stands during the same period. Similarly, the resemblance of the curve for white pine reproduction under 10 years of age in the control area to that of advance growth in the shore reservation area, Figure 6, also indicates reliability of the age separation of the reproduction.

From Table 9 it may also be noted that total stocking to either red or white pine, grouping recent reproduction together with advance growth, is 34% for the shore reservation, and 30% for Cut 'A'. Both these percentages are somewhat higher than the corresponding figure, 29%, in the control area. The per cent stocking in the interior of the cutover, 22%, is exactly the same as the per cent stocking in the interior of the control. Accordingly, it appears that overall per cent stocking to pine has been very slightly improved, (apparently mostly to red pine), by seeding in from shore reservation stands.

Examination of the stocking data for white spruce, black spruce, and balsam fir reveals no significant correlation with the different seeding conditions along the transects.

D - Aesthetics

Apart from the effects of a shore reservation on tree reproduction and on vegetation, its primary purpose is to preserve in its natural state the wilderness beauty of major lakes and canoe routes in woodland parks. It is agreed among conservationists that commercial clearcutting to the lakeshore in these areas leaves an unnatural and undesirable scar on the landscape. It is claimed by woods operators on the other hand, that shore reservations suffer so severely from accelerated depreciation, such as windthrow and natural stand mortality, that the reservation is either a total loss, or at least a broken remnant, long before the new stand has healed the scar. It is suggested that to leave such wastage of broken and fallen timber is both a poor management practice, and an insult to the tourist.

As might be expected, there is some justification for both points of view. Photographic prints 1 and 2 illustrate how successful the shore reservation can be in concealing a cutover. In certain places it is difficult to discern without walking a short distance into the stands, whether or not cutting has taken place behind the shore reservation. Year-round residents of the Basswood Lake area for the past five or six years

Print 1

Print 2

did not know that cutting had taken place on Norway Point, Figure 2. This fact is a striking example of the virtually complete concealment of logging operations through the reservation of stands along the shoreline.

Print 3 illustrates three cleared areas on the west side of Canadian Point, Figure 2, that were used as log rollways to the lake. These rollways and the site of the general camp which was located further north along the same shore, (no illustration), were both cut to the edge of the lake, and are the only places along the west shore of Canadian Point where signs of the logging operation carried out beyond the shore reservation are clearly evident from the lake.

The shore reservations in the Norway Point area were favoured in that no part of them was unduly exposed to excessive damage from wind. Other areas less favoured were severely damaged in a few places, as was pointed out in section A. Print 4 illustrates such damage in the vicinity of transect 5, Figure 2, on the east side of Canadian Point. Print 11 also illustrates a similarly wind-damaged area in the vicinity of transect 7, but viewed from just inside the cutover. The stands on both these areas appear to be merely thinned.

Print 3

Print 4

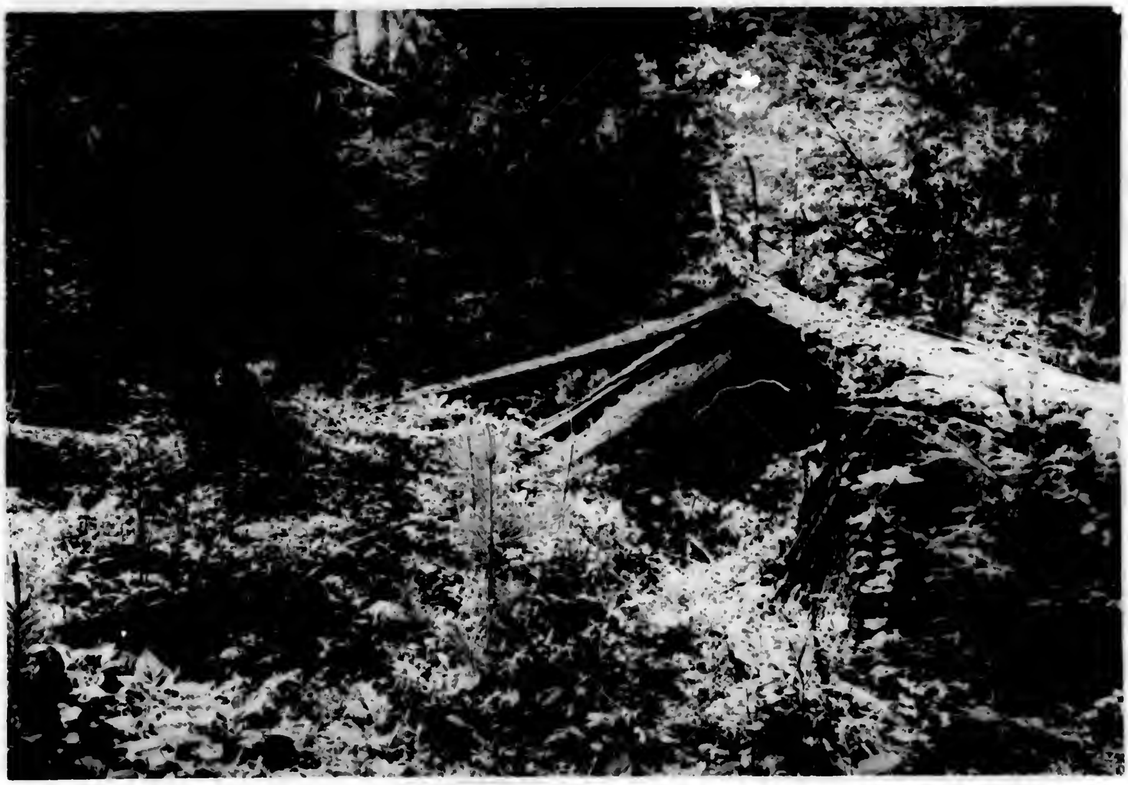
The extreme waste in these two places is not readily apparent, since the wind-thrown timber was salvaged from Basswood Lake the year after logging had been completed.

The severity of wind damage may be observed in Print 5, taken along transect 15 in the Sunday Bay area. Part of the damage there has obviously to be attributed to the poor quality of the trees themselves. Heart rot and shake is often an important factor contributing to wind damage.

In local areas where spring run-off tends to settle in a moderately deep sandy loam, trees are often windthrown. Print 6, also from the Sunday Bay area, illustrates this. Wind-throw of this type, from water-logged soil, has accounted for more than half the wind damage recorded in the area, including that illustrated in Prints 4 and 11. A major part of the remaining wind damage consists of hollow and rotten stems that have blown down.

In many areas the soil is not deep enough to permit water-logging. Print 7 illustrates this not unusual soil condition. Wind damage is uncommon on this soil, often because the stems are shorter than those on deep moist soils.

The transition from an almost clear forest floor under the shore reservation to a heavy vegetative cover in the cutover, is illustrated in Print 8. Though the transition is not always as sharp as is shown here, it



Print 5

Print 6

Print 7

Print 8

may be assumed that the influences of the cutover do not extend very far into the shore reservation. Slash from the logging operation of 10 years ago is seen in the foreground, well back from the edge of the lake.

Prints 9 to 14 illustrate the shore reservation as viewed from the cutover, and the reproduction associated with that area of the cutover bordering the shore reservation. Print 9 shows a shore reservation open to the west, but well preserved because it is on a well-drained upland site. A stand of young white pine in the foreground is developing from advance growth reproduction. Print 10 illustrates a similar condition in a control area where no cutting had taken place. It was observed that reproduction is common in a great many uncut stands.

As was pointed out earler, wind damage in the vicinity of transect 7, illustrated in Print 11, has been severe. The low-lying ground in the foreground of this illustration was once nearly covered with standing pine. Almost all of it has since been windthrown. These trees were quite tall, and were rooted in a loose silt-loam, which periodically tended to become excessively wet. In addition, this stand was located in a gulley extending southwest from the shore reservation to a wider valley. The hills on each dide

Print 9

Print 10

Print 11

Print 12

of the gulley are so located that southwest winds are funneled out of the cutover, through the shore reservation, (blowing it down), and onto the lake. This funnelling effect is a serious threat to the shore reservation wherever it occurs.

Print 12, in the vicinity of transect 9, illustrates a tall stand of white pine in the lee of a hill. It is undamaged by wind. The proximity of the lake may be observed on the left just above the hazel leaves. Note that the hazel and birch have developed in the protected site, while higher, more exposed sites in the foreground are open grass. These sites appear to be still receptive to pine reproduction.

The only area where a number of trees are dying from unknown causes, possibly exposure, is illustrated in Print 13. The same print is also the only illustration obtained of the increase in stocking to red pine reproduction, foreground, associated with that strip of the cutover closest to the shore reservation, discussed in the last section. Excellent white spruce reproduction, (not illustrated), may also be observed in this vicinity.

An illustration of good white pine reproduction, much of it advance growth, is given in Print 14. Print 15, on the other hand, taken in the interior of the cut-over stands, illustrates that good white pine reproduction is not necessarily associated with the shore

Print 13

Print 14

reservation. In fact, it was observed that good white pine reproduction is more closely associated with local areas where the basal area of the previous stand was particularly high.

Print 16 illustrates the more or less usual condition of the cutover away from the influence of the shore reservation. Hazel, birch, and balsam fir, with frequent white pines, make up most of the cover in the high bush layer. Red pines are very infrequent. Both balsam fir and white pine are dying from shoestring rot, Armillaria mellea (Vahl.) Quel., or mouse damage at the root crown, both of which were observed frequently. Print 17 illustrates a south exposure of the cutover on which brush and ground cover are both restricted, red pines are very unusual, and white pines have not readily responded to release.

Red pine reproduction was observed to be heaviest where the available seed fell on some disturbance of the forest litter and soil material. Print 18 illustrates the red pine reproduction established on a log rollway surrounded by a shore reservation. Since most of the rollways had been leveled off mechanically, mineral soil was exposed at the time of the logging operation and during subsequent seeding in. Young stands such as these, apparently made possible solely by the presence of shore reservations and seed available from them, will conceal scars along the shoreline of Basswood Lake within a few years.

Print 15

Print 16

Print 17

Print 18

III - CONCLUSIONS

As a result of the observations and investigations presented here, the following conclusions may be drawn:

1/ that for red and white pine stands, 120 to 200 years old and already showing a negative net increment, there is no greater mortality of trees from causes other than windthrow, in the shore reservations than in the control areas where no cutting has taken place.

2/ that wind damage is about four times as great in the shore reservations as in the control, but damage during the 10-year period since logging is still less than 20 per cent of the shore reservation stand basal area. Natural wind damage in control stands is about five per cent of the stand basal area during the same 10 years.

3/ that wind damage is extremely local in occurrence. Three-fourths of all the wind damage encountered is on only five of the 30 shore reservation samples. Even at the time of logging, blowdown would have seemed most probable in these five places. If they had been cut along with the rest of the cutover, it appears that the real wastage resulting directly from the practice of

leaving shore reservations would have been almost eliminated.

4/ that there has been no improvement in growth rate of the trees along the edge of the shore reservation, except small spruce and balsams.

5/ that development of brush species is somewhat restricted by the shore reservations in a strip of cutover two or three chains wide, running alongside the shore reservation. A proportionate increase in ground layer vegetative cover may be observed for this area.

6/ that the shore reservation, and any seed available from it has had no apparent effect on the pattern of white pine reproduction since logging.

7/ that the shore reservation, and seed available from it, has aided very significantly in seeding in to red pine a strip of cutover two or three chains wide, adjacent to the shore reservation.

8/ that overall stocking to red or white pine in the shore reservation - 34 per cent - is only a slight improvement over the natrual stocking in the control shoreline stands.

9/ that commercial clear-cutting of pine along lakes can be completely concealed, when conditions are favourable, by the reservation of shoreline stands of pine along the lake.

10/ that by careful examination of logging operations where shoreline reservations have been left, and have blown down, it is possible to become familiar with the site conditions conducive to local places of failure. Such areas should have been marked out to be cut right to the lakeshore. The logging scar will be open to view from the lake whether by cutting or by subsequent windthrow. In general, it appears that places of failure are associated with: a) wind channels running between moderate hills out of the cutover onto the lake in the direction of the prevailing wind; b) any pockets of deep till where spring or fall moisture excess could accumulate and dissipate the strength of the rooting load; c) local areas where trunk rot has developed in a major proportion of the trees of the stand.

11/ that the practice of leaving shore reservations keeps logging slash well back from the edge of the lake, and leaves a neater shoreline in keeping with the maintenance of a natural park.

12/ and further, that the practice of leaving shore reservations ensures a good supply of seed available to the shoreline areas to regenerate logging roads, log rollways, and natural openings in the shore reservations themselves, develops a closed cover soon after logging, and maintains it.

Appendix I

DIB - Dbh-ob Conversion

Since the record of trees cut in the cutover areas was made from diameter inside bark measurements, these data had to be converted into Dbh-ob measuremnts before basal areas could be computed. This was necessary in order that the data be comparable to the basal areas computed for the shore reservation, and control area. White pine stem analysis data from Pakesley, 1921, were used for the conversion. No red pine data were available. The DIB measurements of the Pakesley data were grouped and averaged, and plotted over the Dbh-ob averages for the same groups. A curve was drawn, and a Dbh-ob measurement was read off for each stump DIB class. These measurements are tabulated in the following table.

Stump DIB	Dbh-ob (from curve)
9	8.8
10	9.8
11	10.7
12	11.7
13	12.7
14	13.7
15	14.7
16	15.6
17	16.6
18	17.6
19	18.6
20	19.5
21	20.5
22	21.5
23	22.5
24	23.5

Appendix II

GROWTH MEASUREMENT DATA

Transect	First 66 feet (from lake) Dbh	Age at BH	Growth Dbh" Last 10 yrs.	Growth Dbh" Prev. 10 yrs.	Third 66 feet Dbh	Age at BH	Growth Dbh" Last 10 yrs.	Growth Dbh" Prev. 10 yrs.	Last chain to cutover Dbh	Age at BH	Growth Dbh" Last 10 yrs.	Growth Dbh" Prev. 10 yrs.
					Shore Reservation Transects - A, B, C, and D							
	Red pine											
	9.0	123	0.15	0.10	13.0	180	0.75	0.30	16.5	194	0.15	0.15
A	9.0	153	0.25	0.20	15.1	182	0.50	0.35	16.0	188	0.10	0.10
	8.8	148	0.15	0.10	9.2	177	1.00	0.25	13.5	176	0.20	0.15
	13.6	181	0.20	0.15								
	15.1	145	0.60	0.95	12.5	183	0.30	0.25	15.0	187	0.30	0.15
B					13.5	177	0.30	0.20	15.5	178	0.20	0.15
					18.3	185	0.30	0.25				
	5.0	98	0.15	0.10	11.7	-	0.15	0.15	12.7	177	0.15	0.10
	7.1	121	0.10	0.40	12.0	171	0.25	0.15	8.5	-	0.75	0.30
	11.3	117	0.15	0.95	10.1	178	0.25	0.15	14.0	-	0.17	0.15
C	8.6	115	0.30	0.60	12.3	168	0.30	0.10	11.9	177	0.30	0.25
	9.5	168	0.20	0.20	12.4	175	0.50	0.25	9.0	167	0.05	0.10
	11.0	167	0.20	0.20	12.0	177	0.40	0.10				
	11.5	163	0.25	0.10								
	12.6	102	0.60	0.50	9.0	123	0.25	0.20	11.0	119	0.45	0.40
	14.9	114	0.60	0.50	13.3	-	0.25	0.20	10.5	119	0.25	0.25
D					15.5	128	0.25	0.25	12.6	128	0.40	0.20
									10.8	129	0.30	0.15
									9.3	120	0.30	0.25
									10.4	127	0.75	0.55
									10.8	123	0.20	0.25
Total		1915	3.50	4.70		2204	4.70	3.10		2309	5.02	3.65
N		14	14	14		13	15	15		15	17	17
Average		137	0.25	0.33		170	0.31	0.21		154	0.30	0.21
					Control Transect E							
	Red pine											
	17.2	180	1.10	0.90	15.0	188	0.60	0.50	11.5	186	0.50	0.50
					17.0	187	0.40	0.40	18.0	-	0.55	0.50
									14.1	-	0.35	0.40
									15.7	195	0.50	0.55
									14.2	174	0.30	0.30
									10.7	181	0.20	0.30
									14.5	-	0.40	0.40
									16.7	192	0.35	0.25
									15.5	180	0.60	0.50
									8.5	178	0.20	0.25
									16.5	179	0.20	0.15
									17.0	-	0.40	0.30
									12.0	171	0.65	0.35
Total		180	1.10	0.90		375	1.00	0.90		1635	5.20	4.75
N		1	1	1		2	2	2		9	13	13
Average		180	1.10	0.90		188	0.50	0.45		182	0.40	0.27

Appendix II (cont.)

GROWTH MEASUREMENT DATA

Transect	First 66 feet (from lake)				Third 66 feet				Last chain to cutover			
		Age at	Growth Dbh"			Age at	Growth Dbh"			Age at	Growth Dbh"	
	Dbh	BH	Last 10 yrs.	Prev. 10 yrs.	Dbh	BH	Last 10 yrs.	Prev. 10 yrs.	Dbh	BH	Last 10 yrs.	Prev. 10 yrs.
	Shore Reservation Transects - A, B, C, and D											
	White pine											
A	10.2	142	0.35	0.35								
B	20.0	123	1.30	1.10	6.3	130	0.10	0.05				
	17.5	125	0.80	0.80	8.0	117	0.35	0.35				
D	22.1	178	1.75	2.20	7.0	109	0.15	0.10	6.4	109	0.10	0.10
	12.5	-	0.40	0.45					10.3	129	0.10	0.15
Total		568	4.60	4.90		356	0.60	0.40		238	0.20	0.25
N		4	5	5		3	3	3		2	2	2
Average		142	0.92	0.98		119	0.20	0.13		119	0.10	0.13
	White cedar											
A	5.1	-	0.46	0.40	7.8	-	0.30	0.30				
	9.1	-	0.45	0.50	7.0	90+	0.30	0.35				
	9.8	150+	0.20	0.25	5.5	60+	0.95	0.85				
	5.2	-	0.30	0.35								
C	9.8	-	0.30	0.30	6.5	-	0.85	0.70				
Total		150+	1.71	1.80		150+	2.40	2.20				
N		1	5	5		2	4	4				
Average		150+	0.34	0.36		75+	0.60	0.55				
	Balsam fir and White spruce											
A	7.7				2.6	58	0.35	0.35	4.0	28	2.20	0.80
					3.3	55	0.30	0.30	8.5	114	1.50	0.40
B	77.7	40+	0.55	0.40								
	3.7	67	0.20	0.25								
C					6.1	112	1.20	0.30	5.0	23	2.80	1.60
D									3.5	59	1.20	0.85
									3.5	24	1.95	1.30
Total		107	0.75	0.65		225	1.85	0.95		248	9.65	4.95
N		2	2	2		3	3	3		5	5	5
Average		54	0.38	0.33		78	0.62	0.32		49	1.93	0.99

No material from control line - Transect E.

Appendix III

STAND TABLE OF MERCHANTABLE BASAL AREAS - RED AND WHITE PINE

		Control Shoreline Stands					Shore Reservations		
Dbh Class	Areas of Circles	n Per Acre NOW	B.A. Per Acre NOW	Dbh 10 yrs. Ago[i]	Areas of Circles	B.A. 10 yrs. Ago	n Per Acre NOW	B.A. Per Acre NOW	B.A. Per Acre 10 yrs. Ago[ii]
12	0.785	9.2	7.22	11.55	0.728	6.70	9.3	7.30	6.77
13	0.922	9.2	8.48	12.55	0.859	7.90	12.5	11.53	10.74
14	1.069	6.2	6.63	13.55	1.002	6.41	11.7	13.47	12.63
15	1.227	10.7	13.13	14.55	1.155	12.36	8.6	10.55	9.93
16	1.396	7.7	10.75	15.55	1.319	10.16	4.7	6.56	6.20
17	1.576	6.1	9.61	16.55	1.494	9.11	6.2	9.77	9.26
18	1.767	4.6	8.13	17.55	1.680	7.73	2.3	4.06	3.86
19	1.969	7.7	15.16	18.55	1.877	14.45	3.1	6.10	5.82
20	2.182	1.5	3.27	19.55	2.085	3.13	3.9	8.51	8.13
21	2.405			20.55	2.304		0.8	1.92	1.84
22	2.640	1.5	3.96	21.55	2.533	3.80	3.1	8.18	7.85
23	2.885	1.5	4.33	22.55	2.774	4.16			
24	3.142			23.55	3.025		0.8	2.51	2.42
25	3.409	1.5	5.11	24.55	3.288	4.93			
26	3.687			25.55	3.560		0.8	2.95	2.85
27	3.976			26.55					
28	4.276			27.55	4.140		0.8	3.42	3.32
TOTAL			95.78[iii]			90.84		96.83	91.62

i - d.b.h. classes have been decreased by the 10-year diameter increment, 0.45 inches, computed from growth measurements on 40 red and white pines, 12" and up.

ii - computed from values of d.b.h. 10 years ago, used in the shoreline stands.

iii - slightly less than the value computed on Table 1, because the basal area of spruce was not included in this table.

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